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INSTRUMENTS THAT STAY ACCURATE

# OPERATOR'S MANUAL

**WARNING**

For safety of operator, it is essential that this manual be carefully read before the instrument is used for any measurements.

MODEL 2830
3-½ DIGIT
DIGITAL PANEL INSTRUMENT

**SIMPSON ELECTRIC COMPANY**

**5200 W. Kinzie St., Chicago, Illinois 60644**
**Area Code 312, Telephone 379-1121**
**In Canada, Bach-Simpson, Ltd., London, Ontario**

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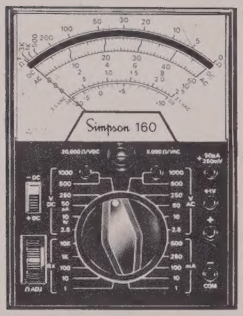


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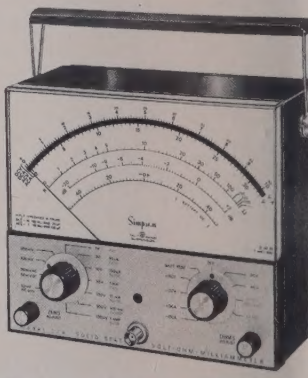

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# OPERATOR'S MANUAL

## MODEL 2830
## 3-½ DIGIT
## DIGITAL PANEL INSTRUMENT

**SIMPSON ELECTRIC COMPANY**

5200 W. Kinzie St., Chicago, Illinois 60644
Area Code 312, Telephone 379-1121
In Canada, Bach-Simpson, Ltd., London, Ontario

Printed in U.S.A.
1-73 JMO HINZ

Part No. 5-116152

Figure 1-1. Model 2830, Digital Panel Instrument

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## WARNING

**The Model 2830 is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to do so can result in a serious or fatal accident.**

**SHOCK HAZARD** (As defined in Underwriters Laboratories Radio and Television Receiving Appliances Standards for Safety, Twelfth Edition, dated June 25, 1969.)

"Shock hazard shall be considered to exist at any part involving a potential of between 42.4 volts peak and 40 kilovolts peak in the following cases:

A. If the current through a load of not less than 500 ohms exceeds 300 milliamperes after 0.0003 second.

B. If the current through a load of not less than 500 ohms exceeds 5 milliamperes after 0.2 second.

C. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.1 and 0.2 second, and the total quantity of electricity passed through the load up to that time exceeds 4 millicoulombs.

D. If the time required for the current through a load of not less than 500 ohms to decrease to 5 milliamperes is between 0.03 and 0.1 second, and the total quantity of electricity passed through the load up to that time exceeds $75T\text{-}350T^2$ millicoulombs, where T is the time in seconds.

E. If the potential is more than 5 kilovolts peak and if the total capacitance of the circuit is more than 3000 micromicrofarads."

NOTE: Additional factors may apply when potentials more than 40 kilovolts peak are present.

# SECTION I

# INTRODUCTION

## 1.1 GENERAL

**1.1.1** The Model 2830 is a precision, 3-1/2 digit, versatile digital panel instrument for use in both portable and laboratory instrumentation or systems. Features include 0.1% accuracy, plug-in modular construction, solid state, integrated circuit electronics, and self contained AC line operation. Additional features are nonblinking LED display, automatic polarity selection and indication, automatic zeroing with separate offset adjustment, excellent temperature characteristics, up to 1000 megohm input resistance (for DC voltage models), fast response time, and 100% overranging capability with automatic out-of-range indication.

**1.1.2** The Model 2830 is designed to measure DC voltage and DC current as specified in Table 1-1. An "up-down" integration technique is used for the analog-to-digital conversion because of its inherently excellent stability, accuracy, and noise immunity. Optimized application of integrated circuit technology achieves high reliability, and a compact design.

**1.1.3** AC line operation and 100 mV full range sensitivity

allow the Instrument to be used as a direct replacement for analog type panel meters. This feature makes it convenient to convert existing instruments or systems from analog to digital display, and at the same time improve their performance specifications.

**1.1.4** The Model 2830 is especially suitable for system type applications. The internal packaging consists of three plug-in printed circuit boards. These are an A/D (analog to digital) converter board, a digital display board, and a power supply board. The boards can be plugged together as a self-contained unit or installed remotely for custom applications (see Figure 1-2).

**1.1.5** For general type applications, the Instrument can be used as a self-contained panel mounted unit, operating from a 117 or 234 volts AC (50 to 400 Hz) power source (check label on top of case).

**1.1.6** The digital display is a 7-segment type, has 3-1/2 digits, 0.33" high, and uses light-emitting diodes (LED). The combination provides easy viewing from a distance or at wide angles, solid state ruggedness and long life. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination.

**1.1.7** The Model 2830 is available in nine models: Four DC voltage ranges, and five DC current ranges, each with 0.1% measurement accuracy. Maximum indication of these

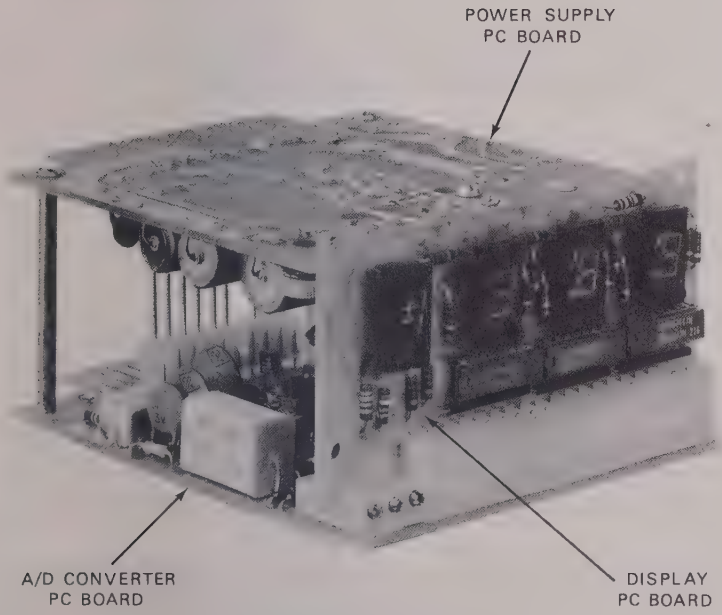



Figure 1-2. Model 2830, Internal Packaging

instruments are ±199.9 mV, ±1.999 V, ±19.99 V, ±199.9 V, ±19.99 μA, ±199.9 μA, ±1.999 mA, ±19.99 mA, and ±199.9 mA.

## 1.2 INSTRUMENT OPTIONS AVAILABLE

BCD (binary coded decimal) output: See Table 1-1, Technical Data, item 7.

## 1.3 SPECIAL VERSIONS (OEM basis only)

**1.3.1** The Model 2830 can be supplied with different power supply and display boards for applications requiring different types of digital displays ("Nixie", "fluorescent", "neon", etc.) and/or power sources. The Instrument is also available less power supply, and/or display board, and with programmable decimal points and other special features.

**1.3.2** Model 2830 less power supply: External DC voltages required are: +5.0 V, 350 mA; +15 V, 20 mA; and -15 V, 20 mA. All voltage tolerances must be within ±5%. The maximum allowable ripples are: 50 mV peak-to-peak for +5.0 VDC, and 20 mV peak-to-peak for ± 15 VDC. All voltage regulations must be 1% or better.

**1.3.3** Model 2830 less display: Provides an economical analog-to-digital converter with BCD output for interfacing with other digital system components such as digital con-

trollers, printers, punched tape storage, and other data acquisition/computer interface devices.

**1.3.4** Model 2830 with programmable decimal: Provides three position externally programmable decimal selection.

**1.3.5** Model 2830 less case: The Instrument is designed as a self-contained, self-supporting unit for custom applications where the case is not required, and the user supplies his own front panel bezel (see Figure 1-2).

## 1.4 TECHNICAL DATA

Table 1-1 lists the Technical Specifications for the Model 2830 Digital Panel Instrument.

Table 1-1
Model 2830 Technical Data

**1. DC Voltage:**

| *Range | Maximum Indication | Input Impedance | Overload Protection | Catalog Number |
|---|---|---|---|---|
| 100mV | ±199.9mV | ≥100MΩ | 300V | 22960 |
| 1V | ±1.999V | ≥1000MΩ | 300V | 22961 |

## 1. DC Voltage (Cont.):

| *Range | Maximum Indication | Input Impedance | Overload Protection | Catalog Number |
|---|---|---|---|---|
| 10V | ±19.99V | 10MΩ | 300V | 22962 |
| 100V | ±199.9V | 10MΩ | 300V | 22963 |

| | |
|---|---|
| Accuracy: | From +15°C to +35°C: ±0.1% of reading ± 1 digit |
| Input Bias Current: | 1 nA maximum at reference conditions (see item 8 below) |
| Resolution: | 100 microvolts (for 100 mV range unit) |
| Temperature Coefficient: | From 0°C to +50°C: ±0.01% per °C |
| Full Range Step Response: (to rated accuracy) | Less than 600 milliseconds |
| Normal Mode Rejection: | 30 dB minimum at 60 Hz. |
| Common Mode Rejection: | 80 dB minimum with 1kΩ unbalance at 60 Hz. |

*Based on a numerical indication of 1000

## 2. DC Current:

| *Range | Maximum Indication | *Voltage Drop | Maximum Input Current | Catalog Number |
|---|---|---|---|---|
| 10uA | ±19.99μA | 100mV | 5mA | 22965 |
| 100uA | ±199.9μA | 100mV | 14mA | 22966 |
| 1mA | ±1.999mA | 100mV | 50mA | 22967 |
| 10mA | ±19.99mA | 100mV | 140mA | 22968 |
| 100mA | ±199.9mA | 100mV | 1A | 22969 |

| | |
|---|---|
| Accuracy: | From +15°C to +35°C: ±0.1% of reading ± 1 digit |
| Resolution: | 10 nA (for a 10 uA range unit) |
| Temperature Coefficient: | From 0°C to +50°C: ±0.01% per °C |
| Full Range Step Response: (to rated accuracy) | Less than 600 milliseconds |
| Normal Mode Rejection: | 30 dB minimum at 60 Hz. |
| Common Mode Rejection: | 80 dB minimum with 1kΩ unbalance at 60 Hz. |

*Based on a numerical indication of 1000

| | | |
|---|---|---|
| 3. | **Input Isolation:** | 250 VRMS (power frequency) between power line ground and circuit ground. |
| 4. | **Conversion:** | |
| | Technique: | "Up-down" integration. |
| | Rate: | Internal trigger, five per second standard (special up to 30 per second). |
| | External trigger: | Hold, or sample on command and hold. |
| 5. | **Display:** | |
| | Type: | Seven segment, single plane, light-emitting-diodes (LED) with 0.33" high numerals. |
| | Number of Digits: | Three full digits nonblinking plus overrange "1" digit, nonblinking. |
| | Polarity: | Automatic, with "+" or "–" indication. |
| | Out-of-Range: | Only bottom half of overrange "1" is illuminated; all other digits indicate "0". |

5. **Display (Cont.):**

| | |
|---|---|
| Decimal Point: | Fixed (location depends on range). Three positions, externally programmable available as a special version (refer to 1.3.4). |

6. **Power Requirement:**

| | |
|---|---|
| AC: | 117 VAC or 234 VAC ±10% (check label on top of case) 50 to 400 Hz, 6 watts. |

7. **Control Signals:**

| | |
|---|---|
| Logic: | DTL/TTL compatible (positive logic);<br>High (logic 1): 2 V to 5.25 V, 40 μA max.<br>Low (logic 0): 0 V to 0.5 V, -1.6 mA (sink) |
| Data Ready Signal (end of conversion): | Logic 0 |
| Display Hold: | Last measurement is "held" by con- |

**7. Control Signals (Cont.):**

necting contact 4 to digital ground (contact 9) through a resistance of less than 300 ohms (refer to Figures 3-3 and 4-1).

BCD output (available as an option): Three BCD digits, polarity, over-range "1", out-of-range and decimal points (refer to Figures 3-3 and 4-1).

**8. Reference Conditions:**

Temperature: $23^{o}C \pm 2^{o}C$

Line Voltage: 117 VAC ±2 VAC, or 234 VAC ±4 VAC 50 to 400 Hz

Atmospheric Pressure: 575 to 800 mm Hg

Relative Humidity: 30 to 60%

Sampling Rate: 5 per second

9. **Temperature Range:**

| | |
|---|---|
| Operating Temperature: | $0^{o}C$ to $+50^{o}C$ |
| Storage Temperature: | $-40^{o}C$ to $+60^{o}C$ |

10. **Relative Humidity:** 0 to 90%, noncondensing

11. **Warm-Up Time:** Less than 5 minutes

12. **Dimensions:**

| | |
|---|---|
| Panel Cut-Out: | 4.375″ wide, 2.813″ high |
| Instrument: | 4.87″ wide, 3.125″ high, 4.75″ deep |

13. **Weight:** Approximately 1.50 pounds

## SECTION II

## INSTALLATION

### 2.1 UNPACKING AND INSPECTION

**2.1.1** Examine the shipping carton for any sign of damage prior to unpacking. If there is none, inspect the Instrument and packing material for obvious damage from shock, water leakage, or other causes. Check the electrical performance as soon as possible. If there is any indication of damage, file a complaint with the carrier immediately. Also check that all items are included (refer to Table 7-1).

**2.1.2** Save the shipping carton and packing materials for future storing or shipping of the instrument.

### 2.2 POWER SOURCE REQUIREMENTS

**WARNING**

**Do not attempt to connect the Model 2830 to the AC power source until instructed to do so. Check that the designation on top of case agrees with the power source to be used.**

The Model 2830 is wired at the factory for 117 volts AC operation. For 234 volt operation, consult your nearest Simpson representative.

**WARNING**

**For proper operation, be sure that the power line ground connection of the Model 2830 is securely connected to a**

**good earth (power line) ground. Preferably, use a standard 3-wire line cord, and a 3-wire grounded outlet which conforms to the latest electrical code.**

## 2.3 PANEL MOUNTING INSTRUCTIONS

The Model 2830 is designed to be mounted on panels ranging from 1/16" to 3/16" in thickness without modification. To mount the Instrument, proceed as follows (refer to Figure 2-1).

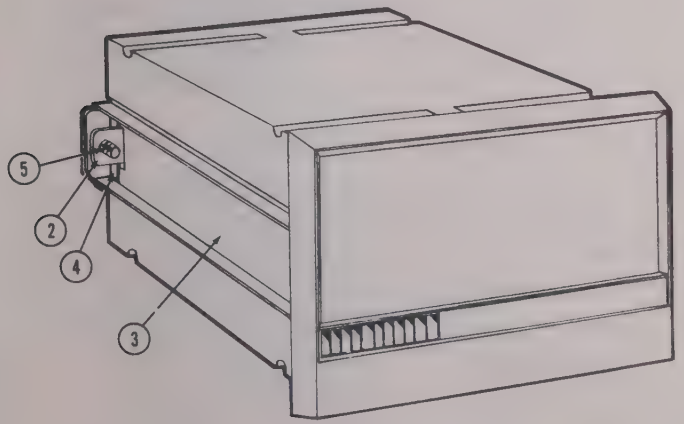



Figure 2-1. Panel Mounting

1. Insert Instrument from front of the panel cut-out (dimensions shown in Figure 2-2).

2. Slide end bracket (item 2) through side slot at the rear of case.

3. Place the side brackets (item 3) along the side of the Instrument and slide the end bracket through the slot in the side brackets.

4. Place two spacers (flat side against the side bracket) between the end and side brackets. Use the spacers marked "1" for .125" panels, spacers marked "2" for .090" panels and spacers marked "3" for .062" panels.

5. Insert two No. 8-32 screws through the side brackets and thread them into the end bracket. Tighten the two screws sufficiently to provide proper mounting rigidity against the front panel. The Instrument is now ready for connector installation (refer to 4.3).

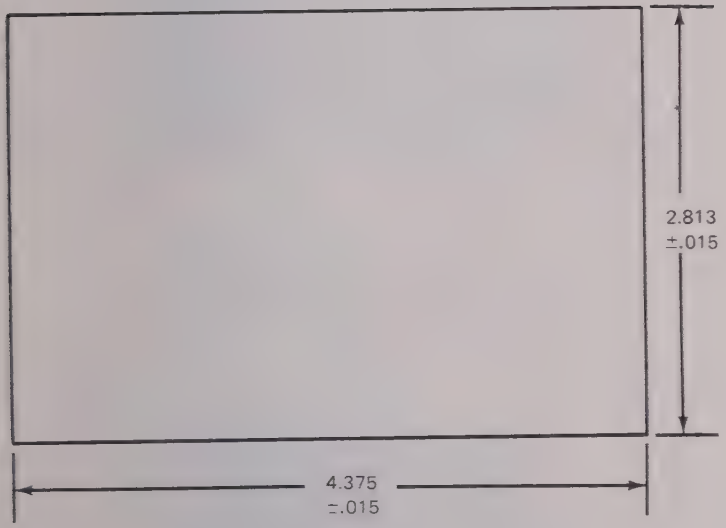



Figure 2-2. Panel Cutout Dimensions

## SECTION III

## CONTROLS, CONNECTORS, AND INDICATORS

### 3.1 GENERAL

All operating and adjustment controls, connectors and indicators are described in Table 3-1. Become thoroughly familiar with each item prior to operating the Instrument for the first time.

Table 3-1
Controls, Connectors and Indicators
Front Panel. (Refer to Figure 3-1)

| | | |
|---|---|---|
| 1. | Digital Display: | The digital display consists of a polarity (+, -) sign, a "1" digit, and three, 7-segment type 0 to 9 digits. It uses LEDs, and displays the polarity and value of the signal being measured. When an out-of-range condition exists (greater than 1999 counts), only the lower half of the "1" digit illuminates and the remaining digits indicate "0". |

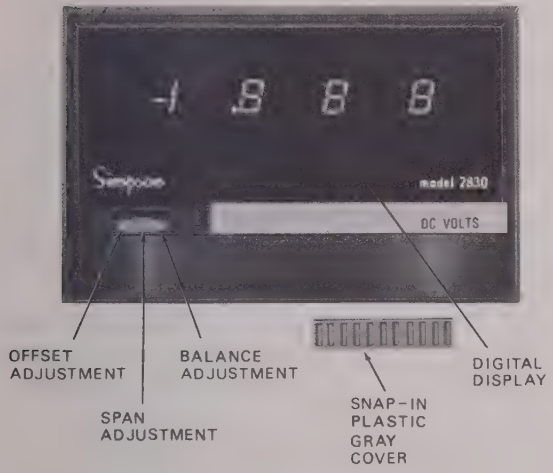



Figure 3-1. Model 2830, Front Panel

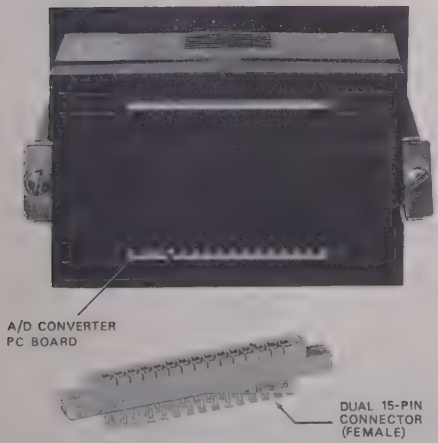



Figure 3-2. Model 2830, Rear Panel

2. *Offset Adjustment: The offset adjustment control is a multi-turn trimmer potentiometer which is screwdriver-adjusted to vary the DC offset voltage of an internal amplifier circuit. It is adjusted to obtain a numerical indication of 000 when the input terminals are shorted together, or when compensating for small offset potentials in the measuring set-up.

3. *Span Adjustment: The span adjustment control is a multi-turn trimmer potentiometer which is screwdriver-adjusted to calibrate the range of the Instrument for positive polarity input signals.

4. *Balance Adjustment: The balance adjustment control is a multi-turn trimmer potentiometer which is screwdriver-adjusted to calibrate the range of the Instrument for negative polarity input signals.

*NOTE: The adjustment potentiometers are located at lower left of front panel behind snap-in gray plastic plate.

Rear Panel. (Refer to Figure 3-2)

5. A/D Converter PC Board: All input and output circuits are available at the contacts on the rear edge of the A/D converter printed circuit board.

6. PC Connector: This connector is a dual 15-pin (female) PC connector, supplied with the Model 2830, which plugs onto the A/D converter PC board. It provides a convenient means for making input power and signal connections to the Instrument. The contact markings, associated circuits and logic levels are contained in Figure 3-3.

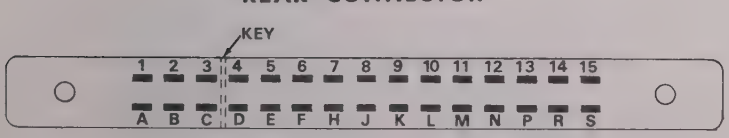



Figure 3-3. Rear Connector Markings and Circuits

Figure 3-3. Rear Connector Markings and Circuits (Cont)

| CONNECTOR CONTACT | CIRCUIT | LOGIC LEVEL | CONNECTOR CONTACT | CIRCUIT | LOGIC LEVEL |
|---|---|---|---|---|---|
| 1 | **117V AC High | - | A | ** 117V AC Low | - |
| 2 | NC | - | B | Pwr. Line Gnd. | - |
| 3 | NC | - | C | NC | - |
| 4 | Display Hold | - | *D | Out-of-Range | 0 |
| 5 | End of Conversion (Data Ready) | 0 | *E | Over-range "1" (1000 to 1999 counts)<br>< 1000 counts or out-of-range | 1<br>0 |
| * 6 | 1st Dec. Point (1999) | 0 | *F | 1st Digit | 1 |
| * 7 | 2nd Dec. Point (19.99) | 0 | *H | 1st Digit (4) | 1 |
| * 8 | 3rd Dec. Point (1.999) | 0 | *J | 1st Digit (2) | 1 |
| 9 | Digital Ground | - | *K | 1st Digit (8) | 1 |
| *10 | 3rd Digit (100) | 1 | *L | *Polarity Sign:<br>"+"<br>"-" | <br>0<br>1 |
| *11 | 3rd Digit (400) | 1 | *M | 2nd Digit (10) | 1 |
| *12 | 3rd Digit (200) | 1 | *N | 2nd Digit (40) | 1 |
| *13 | 3rd Digit (800) | 1 | *P | 2nd Digit (20) | 1 |
| *14 | 2nd Digit (80) | 1 | R | NC | - |
| 15 | - Input (Analog Gnd.) | - | S | + Input | - |

* Available with BCD Option Version Only.
BCD signals are valid only when End of Conversion circuit is in "0" state.

**Or 230 VAC, depending on unit ordered.

# SECTION IV

# OPERATION

## 4.1 GENERAL

**WARNING**

**The Model 2830 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to do so can result in a serious or fatal accident.**

This section of the manual contains all the information related to operation of the Instrument. Special notes and instructions have also been provided for added safety and convenience.

## 4.2 SAFETY PRECAUTIONS

**4.2.1** The Model 2830 should only be used by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page vi.

**4.2.2** Do not work alone when making measurements where a shock hazard can exist. Notify another person that you are, or intend to make such measurements.

**4.2.3** Remember, voltages may appear unexpectedly in

defective equipment. An open bleeder resistor may result in a capacitor retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured and remove all power from the Model 2830 before making connections or disconnections.

**4.2.4** Locate all voltage sources prior to making any connections.

**4.2.5** For maximum safety, do not touch any leads or the Model 2830 while power is applied to the circuit being measured. Always inspect leads and connectors for cracks, breaks or crazes before each use. If any defects exist replace the defective item immediately.

**4.2.6** Always remove all power from the Model 2830 prior to coming into contact with the rear connections or the interior of the Instrument. Insulate or cover rear connections and connector to prevent accidental electrical contact.

**4.2.7** Use extreme caution when making measurements in an rf circuit where a dangerous combination of voltages could be present such as in a modulated rf amplifier.

**4.2.8** Before the unit is used, be sure that Contact B (Figure 3-3), is firmly connected to a good power line ground (earth). This ground wire is used for safety reasons, and to

shield the transformer primary for minimization of noise pick-up. If the AC power input to the Model 2830 is applied, using a standard 3-wire line cord, grounding will be automatic if the electrical outlet has a third wire ground (latest electrical code). If outlet is a 2-wire system requiring a 3-prong to 2-prong adapter, insure that the third wire (ground) from the adapter is connected to an earth (power line) ground.

**CAUTION**

**Do not "float" the "–" input terminal, contact No. 15 (Figure 3-3), more than 250 volts RMS (power frequency) with respect to the power line ground.**

## 4.3 INITIAL CONNECTIONS AND ADJUSTMENTS

Prior to operation of the Instrument, perform the following checks, connections and adjustments. These checks, connections and adjustments also provide a general functional check.

**4.3.1** AC Power Connections: If the Instrument is to be operated directly from an AC power line, check that the power source used matches the requirements of the unit as marked on the top of the case.

**4.3.2** Provide a standard 3-wire AC line cord and make the appropriate connections to the PC connector (refer to Figures 3-3, 4-1). Do not insert the line cord plug into the AC power outlet until instructed to do so.

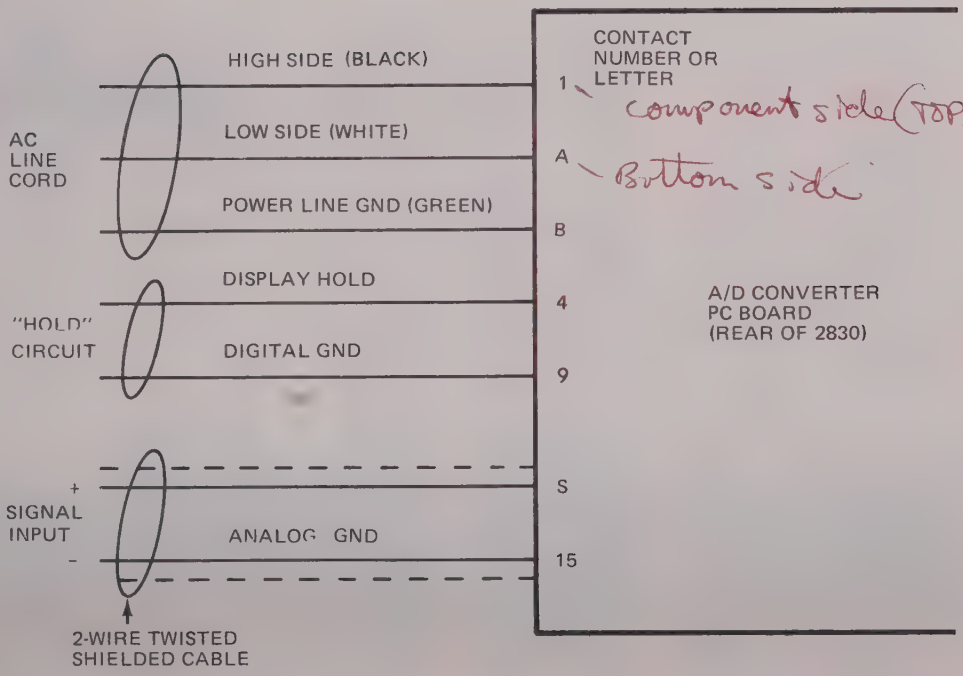



Figure 4-1. Model 2830, Initial Connections

**4.3.3** Signal Input Connections: Connect the signal input leads to the PC Connector, contacts S and 15 (Figures 3-3, and 4-1). Use a twisted, 2-wire shielded cable, particularly when measuring low level signals having a high source resistance.

**4.3.4** "Display Hold" Connections: Connect leads to the PC connector, Contacts 4 and 9 (Figures 3-3 and 4-1).

**4.3.5** Offset Adjustment Check.

a. Insert the PC Connector onto the A/D Converter PC board. Be careful to orient the connector so that its polarizing key lines up with the mating slot on the PC board.

NOTE: The two No. 4-40 x 5/8 screws supplied with the Model 2830 can be used to permanently affix the PC connector onto the Instrument.

b. Short the input leads.

c. Insert the line cord plug in the AC power outlet. Allow the Instrument to warm up for 15 minutes.

d. The indication on the Instrument should be 000. If it is not, offset adjustment is required. Refer to 6.7.4.

**4.3.6** "Display Hold" Check.

a. Connect the input leads to a signal source, which will give an indication between 1000 and 1999.

b. Short the "display hold" leads. Refer to 4.3.4.

c. Remove the input leads from the signal source and short them together. The digital display should indicate the value noted in 4.3.6.a.

d. Remove the short from the "display hold" leads. The display should now indicate 000.

The Instrument is now ready for use.

## 4.4 DC VOLTAGE MEASUREMENT

**WARNING**

**Prior to making measurements review the PRECAUTIONS (refer to 4.2).**

**4.4.1** Accomplish the initial connections and adjustments. Refer to 4.3.

**4.4.2** Prior to connecting input leads remove all power from the circuit being measured and discharge all capacitors.

**4.4.3** Remove the short from the input leads. Determine correct polarity and make connections to the circuit under test. Be careful not to contact adjacent points.

NOTES:

1. Carefully study the circuit characteristics of the signal source. Observe proper grounding/shielding techniques when making inter-connections between the shield of the input cable, analog ground, digital ground, power line ground, and the grounds of the signal being measured.

2. The maximum input bias current for the Model 2830 is 1 nA, and must be remembered when measuring signals having a high source impedance. For example, with a 100 mV full range unit, 1 digit (100 uV) of error will be generated by a source resistance of 100 K ohms. However, this error can be eliminated by the offset adjustment provided the source resistance remains constant.

**4.4.4** Apply power to the circuit being measured. For maximum safety, do not touch the input leads or the Instrument.

**4.4.5** The value of the voltage being measured is indicated on the digital display. When the measurement is completed, remove all power from the circuit being measured, discharge all capacitors, and disconnect input leads.

## 4.5 DC CURRENT MEASUREMENT

**WARNING**

**Prior to making measurements review the PRECAUTIONS (refer to 4.2).**

**4.5.1** Accomplish the initial connections and adjustments. Refer to 4.3.

**4.5.2** Prior to connecting input leads remove all power to the circuit being measured and discharge all capacitors. Remove the short from the input leads, open the circuit in which the current is to be measured, and connect the input leads in series. Observe the correct polarity and insure that the Model 2830 is not connected across a voltage source which might result in a current through the Instrument in excess of the range. Failure to do so can cause damage to the Model 2830.

**4.5.3** Apply power to the circuit being measured. For maximum safety, do not touch the input leads or the Instrument.

**4.5.4** The value of the current being measured is indicated on the digital display.

**4.5.5** When the measurement is completed, remove all power from the circuit being measured and discharge all capacitors.

**4.5.6** Disconnect the input leads and reconnect the circuit which was originally opened.

## 4.6 DISPLAY HOLD OPERATION

**4.6.1** There are some applications where it is advantageous to "hold" a reading. In these applications, a single pole, single throw switch is used and connected to the "display hold" leads (4.3.4). In the "hold" position, the switch is in the "on" position ("display hold" leads are shorted together) and the indication existing at the time the switch is switched to the "on" position is retained. In the "off" position (of the switch) the "hold" is off and the digital indication changes with changes in input signal.

**4.6.2** The hold on-off switch can be a mechanical, electro-mechanical, or electronic switch, locally or remotely controlled.

## SECTION V

## THEORY OF OPERATION

### 5.1 OVERALL SYSTEM

**5.1.1** The basic block diagram of the digital panel instrument is shown in Figure 5-1. It utilizes an "up-down" integration technique for the analog-to-digital conversion. This technique achieves excellent accuracy, stability, and noise immunity.

**5.1.2** The Model 2830 converts an analog DC voltage at the input terminals into a corresponding digital (BCD code) value. The digital information is then decoded and displayed in numeric form on the 7-segment LED display.

**5.1.3** The inputs to the 100mV and 1V full range instruments are connected directly to the input amplifier. The remaining DC voltage ranges are basically 1V full range (1,000 counts) instruments with an appropriate attenuator in the input circuits. The DC current instruments are 100mV full range (1,000 counts) devices, with a precision shunt resistor across the input. The value of the shunt resistor varies depending on the current range of the Instrument.

### 5.2 OPERATION (Refer to Figures 5-1, 5-2)

**5.2.1** The DC voltage to be measured is sampled ap-

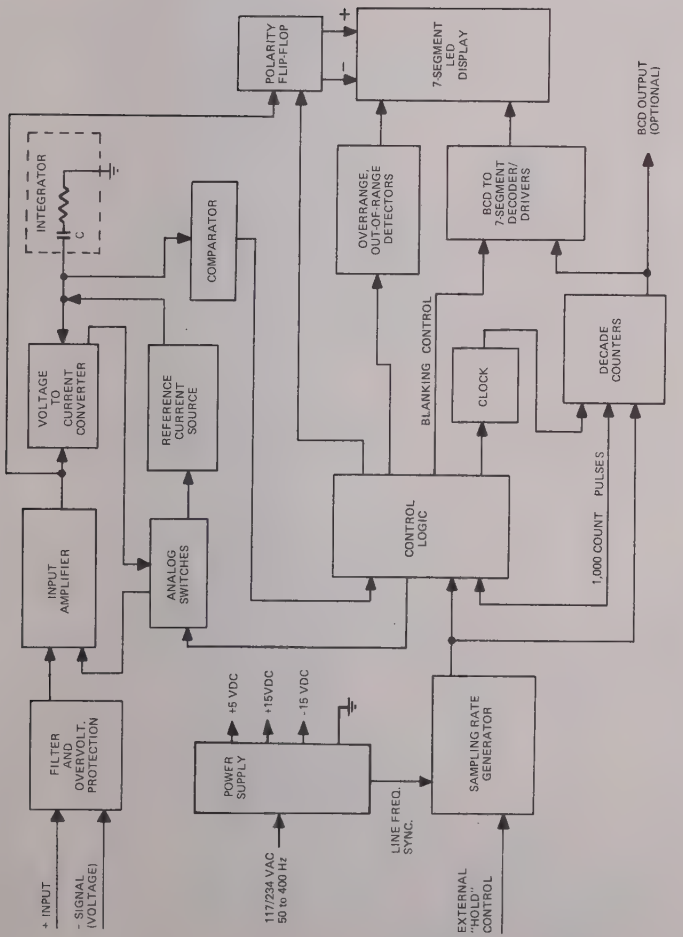



Figure 5-1. Model 2830, Overall Block Diagram

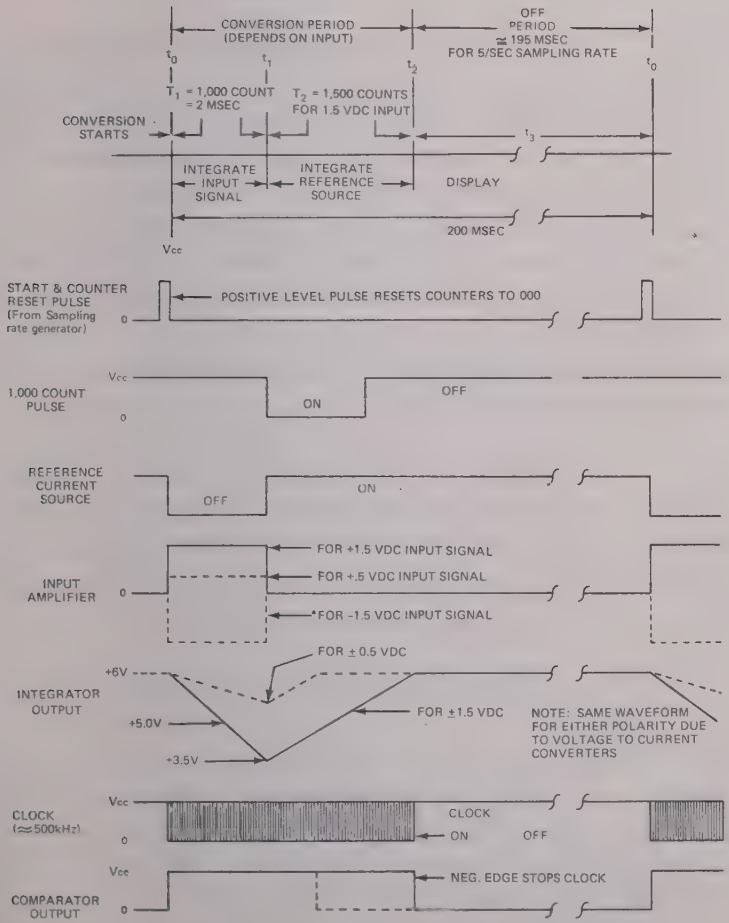
proximately 5 times per second as determined by the Sampling Rate Generator. The sampling rate is synchronized to a submultiple of power line frequency for maximum rejection of interference at power line frequency.

**5.2.2** The sampling interval, T1 (see Figure 5-2 for the basic timing diagram) is initiated by a pulse from the Sampling Rate Generator. This pulse is also used to reset all Decade Counters and flip-flops to their initial state. The measuring interval, T2, is initiated by the first 1,000 count pulse from the Decade Counters.

**5.2.3** At the start of T1, the Clock is turned on, the Decade Counters count pulses at the rate of 500,000 per second, and the Reference Current Source is turned off.

**5.2.4** During T1, the charge stored in the integrating capacitor C1. is removed by the amplified input signal at the output of the Voltage-to-Current Converter circuit, at a rate proportional to the magnitude of the input signal (voltage). Also during this interval, the voltage across the Integrator output decreases (regardless of the polarity of the input signal).

**5.2.5** At count 1,000, the Control Logic circuitry disconnects the output of the Voltage-to-Current Converter from the Integrator input and turns on the Reference Current Source through the Analog Switches. This action starts the measuring interval, T2.




*Shown for a 1 VDC full range unit.

Figure 5-2. Model 2830, Basic Timing Diagram*

**5.2.6** During interval T2, the Reference Current Source restores the charge that was lost during T1, back into the integrating capacitor at a predetermined rate. When the charge reaches the original level (that existed just prior to T1), the Comparator senses this level, changes state and sends a signal to the Control Logic circuit to stop the Clock. At the same time, the Comparator takes away any excess charge that the Reference Current Source returned to the integrating capacitor, the Decade Counters stop counting, and the display is activated. This action ends T2 and starts the time interval T3.

**5.2.7** During T3, the BCD outputs from the Decade Counters are decoded by the BCD to 7-Segment Decoder/Drivers and indicated by the 7-Segment LED Display. The complete cycle then repeats with the initiation of another pulse from the Sampling Rate Generator.

NOTE: The display is disabled during time intervals T1 and T2.

**5.2.8** The other requirements of the Instrument, such as overrange and out-of-range, are accomplished by the Control Logic and Decade counters. The polarity indication is determined by the polarity of the signal at the output of the Input Amplifier.

## 5.3 POWER SUPPLY CIRCUITS

**5.3.1** The circuits for the Model 2830 power supply are shown in Figure 7-1.

**5.3.2** Transformer T1 is a dual-primary power transformer. The two primary windings are connected in series for 234-volt and in parallel for 117-volt operation.

**5.3.3** There are two secondary windings on T1. Both windings step down the input voltage as required by the rectifiers and regulators.

**5.3.4** Regulated DC voltages of +15V and -15V are produced by two half-wave rectifiers, followed by two series type regulators. These regulated voltages are used to supply power to the analog circuits.

**5.3.5** A regulated DC voltage of +5V is produced by a full wave rectifier followed by a series type regulator. The +5V is used to supply power to all digital integrated circuits, control circuits and LED display.

# SECTION VI

# MAINTENANCE

## 6.1 GENERAL

**WARNING**

**This instrument contains internal voltages which constitute a SHOCK HAZARD. Only Simpson Authorized Service Centers or factory personnel should disassemble any part of the Instrument.**

The Model 2830 is carefully designed and constructed with high quality components. By providing reasonable care, and following the instructions in this manual, the user can expect a long, useful service life from his instrument.

## 6.2 WARRANTY

The Simpson Electric Company warranty policy is printed in the inside back cover of the manual. Read carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized Service Center for instructions. These are listed on the last pages of the manual. If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number, and date of purchase. Service or shipping instructions will be promptly sent to you. There will be no charge for repair of the Instrument under warranty

beyond one-way transportation charges. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without prior approval.

## 6.3 SHIPPING

Pack the Instrument carefully and ship it prepaid to the destination indicated. Insure the Instrument.

## 6.4 CASE AND FRONT COVER REMOVAL

The case and front cover can be removed for maintenance purposes as follows:

**WARNING**

**Remove all power and connections to the Instrument prior to removing the case and front cover.**

a. Disconnect the Instrument from the AC power source.

b. Remove PC connector from rear of Instrument.

c. Remove mounting brackets (side and end brackets).

d. Remove Instrument from panel in which it is mounted.

e. Remove the two No. 2-56 screws from rear edges of front cover and lift off cover.

f. Remove the four No. 4-24 screws from top and bottom of case and slide the case halves apart.

g. Reverse the above procedure when replacing the case and front cover.

**CAUTION**

**When re-assembling the case and front cover, take care not to over-tighten the screws, or damage to the plastic case can result.**

## 6.5 DIGITAL DISPLAY

Under normal usage, practically indefinite life can be expected from the LED (light-emitting-diode) digital display. However, if replacement is necessary, the LED required should be replaced only by a Simpson Authorized Service Center or at the Factory repair facility. Two different type LED's are used; therefore, be careful to designate which LED requires replacement (refer to Table 7-2).

## 6.6 LINE FUSE REPLACEMENT

**WARNING**

**Remember to remove all power and all other connections from the Instrument prior to removing the case and front cover.**

**6.6.1** The line fuse is located next to the power transformer as shown in Figure 6-1.

**6.6.2** Remove the case and front cover as described in 6.4.

**6.6.3** Carefully lift the defective fuse from the holder and replace with a type 8AG, or equivalent (refer to Table 7-2 for rating).

**6.6.4** Replace the case and front cover.

## 6.7 OFFSET ADJUSTMENT AND RANGE CALIBRATION

**6.7.1** The Model 2830 has been precisely calibrated at the factory and its high order of accuracy and stability eliminates the need for frequent recalibration. However, should recalibration be required after a long period of time or in order to compensate for the characteristics of external circuits or equipment, use the procedure covered in 6.7.4 and 6.7.5.

**WARNING**

**Prior to making any adjustments review and comply with the precaution notes listed in 4.2 of SECTION IV.**

**6.7.2** All adjustments are accessible from the front panel when the snap-in cover plate is removed. The plate can be

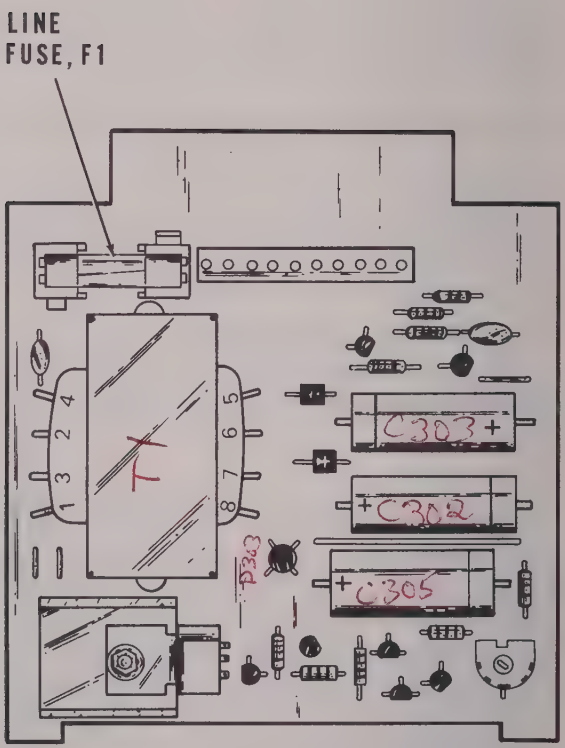



Figure 6-1. Model 2830, Power Supply Board Line Fuse Location
(Viewed from Component Side)

removed by gripping its center and carefully pulling outward. The adjustments are identified in Figure 3-1.

**6.7.3** Apply AC power to the Model 2830 and the calibration equipment allowing a minimum of 15 minutes for warm-up.

**6.7.4** Offset Adjustment:

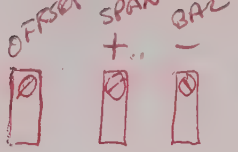
a. Short the input leads (PC connector contacts S and 15), and rotate the offset control until the Instrument displays +000.

b. Now, slowly rotate the control counterclockwise until the polarity sign just changes to "-". This completes the offset adjustment.

**6.7.5** Range Calibration: Two adjustments are provided for range calibration, a span adjustment for positive polarity input signals, and a balance adjustment for negative polarity input signals. The procedure is as follows:

a. Check the offset adjustment (6.7.4) above.

b. Connect the input leads of the Model 2830 to a precision (±0.01% accuracy) voltage or current source (whichever is applicable). Select the lead connections which result in a positive (+) polarity indication.






c. Adjust signal source for a zero output signal. The indication on the Instrument should be 000. If it is not, an offset has been introduced by the calibration set-up. If the offset cannot be eliminated, the offset control can be readjusted to cancel it out.

d. Adjust the output of the calibration source to a value which should cause an indication of 1500. For example, if the Model 2830 being calibrated has a full range sensitivity of 1V DC, adjust the calibration source for an output of 1.5V DC.

e. Rotate the span adjustment control for an indication of +1500.

f. Reverse the input connections to the Instrument to achieve a negative polarity input and then repeat steps c and d above.

g. Rotate the balance adjustment control for an indication of -1500.

h. Recheck both the positive and negative input signal calibration to ensure that both calibration conditions are met.

## 6.8 PREVENTIVE MAINTENANCE

**6.8.1** Daily Care: The case and front cover are made of a

plastic material (ABS polymers) having good chemical resistant and temperature properties. To maintain the Instrument in good condition observe the following:

a. Immediately clean all spilled materials from the Instrument and wipe dry. If the spillage is corrosive, use a suitable cleaner to remove it and neutralize the corrosive action.

b. Whenever possible, avoid prolonged exposure or usage in areas which are subject to: Temperature and humidity extremes, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interference.

**6.8.2** Monthly Care: Verify Instrument accuracy by performing operational checks using known value sources. If repair is necessary, contact the nearest Authorized Simpson Service Center or the factory.

**6.8.3** Annual Care: It is recommended that the Instrument be returned annually to a Simpson Authorized Service Center or Factory for a complete overall check, adjustment, and calibration.

**6.8.4** Storage: When the Instrument is not in use, store it in a location free from temperature extremes, dust, corrosive fumes, and mechanical vibration or shock.

## 6.9 TROUBLE SHOOTING

**6.9.1** If the Instrument does not yield satisfactory results, accomplish the following prior to attempting maintenance on the Instrument.

a. Perform the initial connections in 4.3.

b. Check that the PC connector is wired correctly and inserted properly (see Figures 3-2 and 3-3). Make sure that all contacts on the A/D converter printed circuit board are clean.

c. Check that the value being measured is within the rating of the Instrument.

d. Ensure that the AC power source is within the Instrument specifications, and free from excessive fluctuations and/or transients.

e. Ensure that the environment in which the Instrument is being used is within the Instrument specifications.

f. Inspect the device being measured and the measurement test set-up to insure that proper shielding and grounding techniques have been used. Also check that the Instrument is not affecting the circuit being measured and that the measurement is valid. For example, DC accu-

racy can be affected by transients, or unwanted AC and DC signals introduced by electrostatic, electromagnetic, or capacitive pickup, or existing as part of the signal.

g. If it appears that there is no power, check the AC line fuse. Refer to 6.6 for line fuse replacement.

h. Perform offset and calibration adjustments described in 6.7, if accuracy problems are noted.

**6.9.2** If the steps taken in para. 6.9.1 do not yield satisfactory results, refer to the troubleshooting chart (Table 6-1). This chart contains instructions which can be performed by a qualified technician but do not require specialized knowledge or facilities. All other repairs and adjustments should be directed to a Simpson Authorized Service Center or the Factory.

TABLE 6-1. TROUBLE SHOOTING CHART

| SYMPTOM | PROBABLE CAUSES | CURE |
|---|---|---|
| 1. No indication on the digital readout. | a. Low or no voltage at power source receptacle.<br>b. Line cord disconnected.<br>c. Defective line cord.<br>d. Line fuse open. | a. Restore correct voltage at power receptacle.<br>b. Connect line cord.<br>c. Repair or replace line cord.<br>d. Replace fuse F1. Refer to 6.6. |
| 2. Low or no intensity on one or more of the digital display LED's. | Display LED near end of life. | Replace display LED. Refer to 6.5. |
| 3. Indications fluctuate and/or drift. | | |
| a. Indication OK at 000 with the input terminals shorted and at 1000 using a stable, low impedance input. | a. Fluctuations and/or drift are being generated by the device being measured or the measurement test set-up. | a. Use proper shielding, grounding techniques, and connections to minimize "pick-up" of unwanted signals due to ground loops, poor |

TABLE 6-1. TROUBLE SHOOTING CHART (Cont)

| SYMPTOM | PROBABLE CAUSES | CURE |
|---|---|---|
| 3. (Cont) | | connections, and capacitive and/or inductive coupling.<br>NOTE: If the drift and/or fluctuation is coming from the device being measured, no cure is required and the measurement is valid. Device must be corrected. |
| b. Indications fluctuate and/or drift at 000 with the input shorted and/or at 1000 using a stable and low impedance input. | b. AC power source is low, fluctuating, or contains transients. | b. Correct the power source. |

TABLE 6-1. TROUBLE SHOOTING CHART (Cont)

| SYMPTOM | PROBABLE CAUSES | CURE |
|---|---|---|
| 4. Accuracy not within specifications when checked with a stable, higher accuracy (at least 5 times better) low impedance source. | a. Instrument is out of calbration.<br>b. Instrument not zeroed properly. | Perform offset and calibration adjustment. Refer to 6.7. |
| 5. Accuracy of Instrument is within specifications but measurements appear in error. | a. Instrument affects circuit being measured. | a. Study circuit being measured and Instrument specifications. Correct indications accordingly. |
| | b. Common and/or normal mode rejection specifications are being exceeded. | b. Refer to item 3, Cure. |

## SECTION VII

## REPLACEMENT PARTS AND SCHEMATIC DIAGRAM

TABLE 7-1. ITEMS SUPPLIED WITH THE INSTRUMENT

| QUANTITY | DESCRIPTION | PART NO. |
|---|---|---|
| 1 | Connector, Female, Printed Circuit, Dual, 15-Pin | 5-114381 |
| 2 | Side Bracket, Panel Mounting | 5-115946 |
| 1 | End Bracket, Panel Mounting | 5-114027 |
| 2 | Screw, Machine No. 2-56 X 3/16, Bd. Hd. | 5-180754 |
| 4 | Screw, Thread Cutting, 4-24 X 1/2; Fil. Hd. | 5-144029 |
| 2 | Screw, Machine No. 4-40 X 5/8, Rd. Hd. | 1-134781 |
| 2 | Screw, Machine No. 8-32 X 3/4, Bd. Hd. | 5-144028 |
| 2 | Spacer, Rectangular, Stamped No. 3 | 5-114031 |
| 2 | Spacer, Rectangular, Stamped No. 2 | 5-114032 |
| 2 | Spacer, Rectangular, Stamped No. 1 | 5-114033 |
| 1 | Operator's Manual | 5-116152 |

TABLE 7-2. REPLACEMENT PARTS

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| C101, C102 | Capacitor, .1uF, ±10%, 100 VDC | 5-115997 |
| C103, C104, C108 | Capacitor, 20pF, ±10%, 160 VDC | 5-115991 |
| C105, C106 | Capacitor, .1uF, -20%, ±80%, 20 VDC | 5-114521 |
| C107 | Capacitor, .47uF, GMV, 3 VDC | 5-115996 |
| C109 | Capacitor, 47pF, ±10%, 160 VDC | 5-115992 |
| C110 | Capacitor, 27pF, ±20%, 500 VDC | 5-112692 |
| C111 | Capacitor, 1.8uF, ±10%, 100 VDC | 5-115998 |
| C112 | Capacitor, 4.7uF, ±20%, 10 VDC | 5-115999 |
| C113 | Capacitor, .1uF, -20% +80%, 10 VDC | 5-113214 |
| C114 | Capacitor, .001uF, -20%, +80%, 1K VDC | 5-111119 |
| C115 | Capacitor, 1.0uF, ±10%, 16 VDC | 5-115531 |
| C116 | Capacitor, 3900pF, ±5%, 33 VDC | 5-115994 |
| C117 | Capacitor, 150pF, ±20%, 33 VDC | 5-115993 |

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| C301, C304 | Capacitor, .002uF, ±20%, 500 VDC | 5-111426 |
| C302, C303 | Capacitor, 470uF, 25 VDC | 5-116000 |
| C305 | Capacitor, 1500uF, 10 VDC | 5-116001 |
| D101, D102 | Diode, SSD708 | 5-115942 |
| D103, D104, D105 | Diode, IN914 | 5-112004 |
| D106, D107, D108, D109, D110, D111, D301, D302 | Diode, Rectifier, 100 PIV, 10D1 | 5-114005 |
| D112 | Diode, Zener, 6.4V ±5%, IN4576 | 5-116201 |
| D303 | Bridge. Rectifier, 50 PIV. W005 | 5-115945 |
| F1 | Fuse, 1/4 Amp, 8AG U/L | 5-113997 |
| IC1, IC3, IC5 | I.C. Decade Counter SN7490N | 5-114939 |
| IC2, IC4, IC6 | I.C. 7-Segment Decoder Driver SN7447N | 5-115927 |

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| IC7 | I.C. Dual J-K Flip-Flop SN74107N | 5-115926 |
| IC8, IC9 | I.C. Quad 2-Input Nand Gate SN7400N | 5-114943 |
| IC10 | I.C. Quad 2-Input Nor Gate SN7402N | 5-115924 |
| IC11 | I.C. Triple 3-Input Nand Gate SN7410N | 5-115925 |
| IC12 | I.C. Operational Amplifier SN72741P | 5-115928 |
| IC13 | I.C. Transistor Array SG3821N | 5-116151 |
| LED-1, 2, 3 | Readout, LED, 7- Bar with Decimal, SLA-1 | 5-115943 |
| LED-4 | Readout, LED, ±1, SLA-2 | 5-115944 |
| Q101, Q102 | Transistor, Junction Field - Effect KE4416 | 5-115937 |
| Q103 | Transistor, NPN Darlington, GET5306 | 5-115938 |
| Q104, Q105, Q108, Q110, Q304, Q305 | Transistor, PNP, 2N4121 | 5-115939 |

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| Q106, Q107 | Transistor, NPN, 2N4123 | 5-115931 |
| Q111, Q112, Q114. Q116 | Transistor, NPN, GET3646 | 5-115936 |
| Q113 | Transistor, NPN, GET2484 | 5-115935 |
| Q115 | Transistor, Unijunction, 2N6027 | 5-115933 |
| Q301, Q302, Q307 | Transistor, NPN, GET2222 | 5-115934 |
| Q303, Q308 | Transistor, PNP 2N4416 Selected | 5-116479 |
| Q306 | Transistor, NPN | 5-115932 |
| R101, R102, R103, R112, R139 | Resistor, 220KΩ, ±10%, 1/4W | 5-115963 |
| R104 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R105, R114, R123, R138, | Resistor, 15KΩ, ±5%, 1/4W | 5-115959 |
| R306, R309 | Resistor, 15KΩ, ±1%, 1/4W | 5-116482 |
| R106 | Potentiometer, 250KΩ, 20 Turn | 5-116150 |
| R107, R136 | Resistor, 1MΩ, ±10%, 1/4W | 5-113626 |

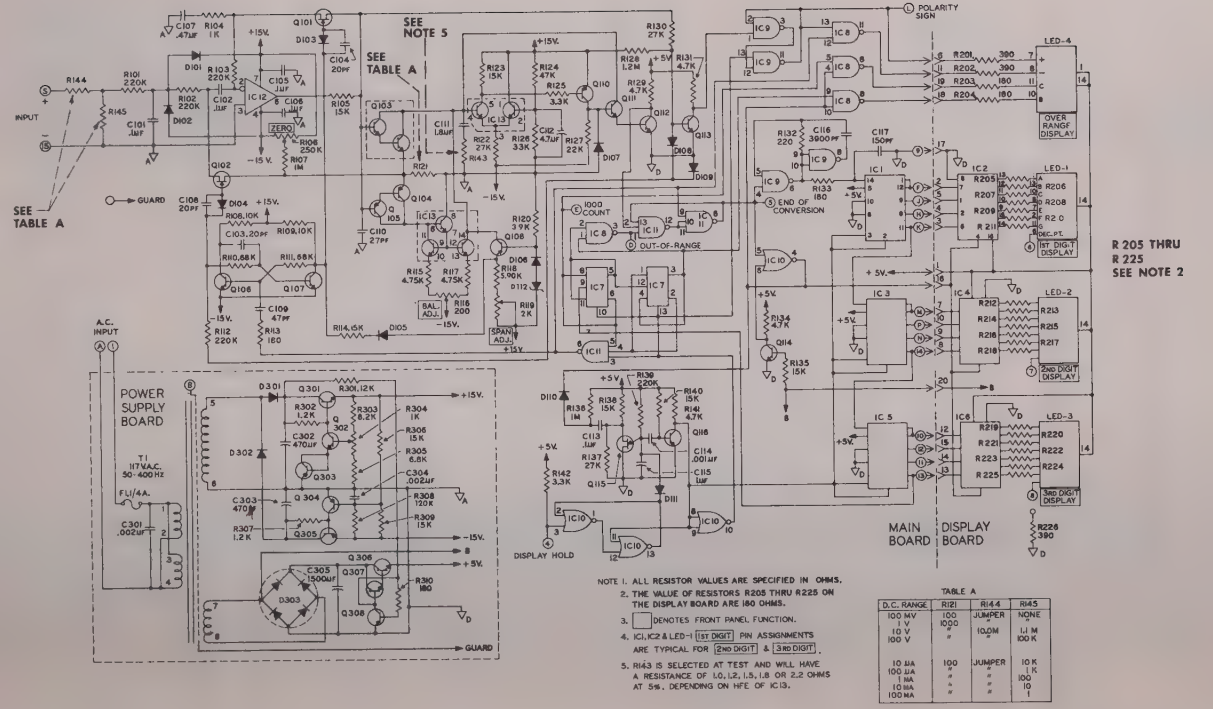
| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| R108, R109, | Resistor, 10KΩ , ±5%, 1/4 W | 5-115958 |
| R120 | Resistor, 3.9KΩ, ±5%, 1/4W | 5-116476 |
| R110, R111 | Resistor, 68KΩ , ±10%, 1/4 W | 5-115962 |
| R113, R133, R203 thru R225, R310 | Resistor, 180Ω , ±10%, 1/4 W | 5-115950 |
| R115, R117 | Resistor, 4.75KΩ , ±1%, 1/8 W | 5-115954 |
| R116 | Potentiometer, 200Ω , 20 Turn | 5-116122 |
| R118 | Resistor, 5.90KΩ, ±1% 1/8W | 5-116478 |
| R119 | Potentiometer, 2KΩ, 20 Turn | 5-116477 |
| R121 | Resistor, 100Ω , ±1%, 1/8 W (See Table A in schematic) | 5-114016 |
| R121 | Resistor, 1KΩ , ±1%, 1/8 W (See Table A in schematic) | 5-116141 |
| R122, R130, R137 | Resistor, 27KΩ , ±5%, 1/4 W | 5-115960 |
| R124 | Resistor, 47KΩ , ±5%, 1/4 W | 5-113628 |
| R125 | Resistor, 3.3KΩ , ±5%, 1/4 W | 5-115952 |

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| R126 | Resistor, 33KΩ ,±5%, 1/4 W | 5-115961 |
| R127 | Resistor, 22KΩ ,±10%, 1/4 W | 5-113623 |
| R128 | Resistor, 1.2 MΩ ,±10%, 1/4 W | 5-114985 |
| R129, R131, R134, R141 | Resistor, 4.7KΩ ,±10%, 1/4 W | 5-113873 |
| R132 | Resistor, 220Ω ,±5%, 1/4 W | 5-115951 |
| R135, R140 | Resistor, 15KΩ ,±10%, 1/4 W | 5-113621 |
| R142 | Resistor, 3.3KΩ ,±10%, 1/4 W | 5-114973 |
| R143 (See schematic, NOTE 5) | Resistor, 1.0Ω ±5%, 1/4 W | 5-116145 |
| | Resistor, 1.2Ω ±5%, 1/4 W | 5-116146 |
| | Resistor, 1.5Ω ,±5%, 1/4 W | 5-116147 |
| | Resistor, 1.8Ω ,±5%, 1/4 W | 5-116148 |
| | Resistor, 2.2Ω ,±5%, 1/4 W | 5-116149 |
| R144 | Resistor, 10.0 MΩ ,±1%, 1/2 W used on 10 and 100 VDC range units | 5-116144 |

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| R145 (See note below) | Resistor, 1.1MΩ , ±1%, 1/8 W used on 10 VDC range unit | 5-116143 |
| | Resistor, 100KΩ , ±1%, 1/8 W used on 100 VDC range unit | 5-116142 |
| | Resistor, 10KΩ , ±1%, 1/8 W used on 10 μADC range unit | 5-113631 |
| | Resistor, 1KΩ , ±1%, 1/8 W used on 100 μADC range unit | 5-115490 |
| | Resistor, 100Ω , ±1%, 1/8 W used on 1 mADC range unit | 5-115949 |
| | Resistor, 10Ω , ±1%, 1/8 W used on 10 mADC range unit | 5-115487 |
| | Resistor, 1Ω , ±1%, 2 Watts used on 100 mADC range unit | 5-116140 |
| R201, R202, R226 | Resistor, 390Ω , ±10%, 1/4 W | 5-113868 |
| R301 | Resistor, 12KΩ , ±10%, 1/4 W | 5-114978 |
| R302, R307 | Resistor, 1.2KΩ , ±10%, 1/4W | 5-114971 |

NOTE: The value of resistor R145 depends upon range of unit purchased.

| SYMBOL | DESCRIPTION | PART NO. |
|---|---|---|
| R303 | Resistor, 8.2KΩ , ±5%, 1/4 Watt | 5-115957 |
| R304 | Potentiometer, 1KΩ, ±20% | 5-115521 |
| R305 | Resistor, 6.8KΩ , ±5%, 1/4 Watt | 5-115956 |
| R308 | Resistor, 120KΩ, ±5%, 1/4W | 5-113627 |
| T1 | Transformer, Power | 5-116125 |
| | A/D Converter, P.C. Board Assy. | 10-862654 |
| | Power Supply, P.C. Board Assy. | 10-862665 |
| | Display, P.C. Board Assy. | 10-862664 |
| | Snap-in Gray Plastic Plate (covers adjustment pots) | 5-114024 |




NOTE 1. ALL RESISTOR VALUES ARE SPECIFIED IN OHMS.

2. THE VALUE OF RESISTORS R205 THRU R225 ON THE DISPLAY BOARD ARE 180 OHMS.

3. [ ] DENOTES FRONT PANEL FUNCTION.

4. IC1, IC2 & LED-1 [1ST DIGIT] PIN ASSIGNMENTS ARE TYPICAL FOR [2ND DIGIT] & [3RD DIGIT].

5. R143 IS SELECTED AT TEST AND WILL HAVE A RESISTANCE OF 1.0, 1.2, 1.5, 1.8 OR 2.2 OHMS AT 5%, DEPENDING ON hFE OF IC13.

TABLE A

| D.C. RANGE | R121 | R144 | R145 |
|---|---|---|---|
| 100 MV | 100 | JUMPER | NONE |
| 1 V | 1000 | " | " |
| 10 V | " | 10.0M | 1.1 M |
| 100 V | | | 100 K |
| 10 μA | 100 | JUMPER | 10 K |
| 100 μA | " | " | 1 K |
| 1 MA | " | " | 100 |
| 10 MA | " | " | 10 |
| 100 MA | " | " | 1 |

Figure 7-1 Model 2830, Schematic Diagram

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